HIGHER ENERGY EFFICIENCY

AN APPROACH TO THE SEVENTH FIVE YEAR PLAN

R.K. Pachauri
G. Anandalingam
Leena Srivastava

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Tata Energy Research Institute
7,Jorbagh
New Delhi 110 003

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Background Scenario

The formulation of the Seventh Five Year Plan comes at a time when the global economy has largely absorbed the second oil price shock of 1979-80. As far as India is concerned this second shock has in many ways produced far more adverse effects on the economy than the first oil shock of 1973-74. But economic developments being witnessed today are the result of effects produced not only through the immediate impacts of post-1979 developments in the world oil market, but also represent the lagged effects of the 1973-74 price increases. In general, it would be valid to say that the immediate short run policy response of the Government of India to the 1973-74 oil price increase was largely effective in curbing the growth of demand in the short run and ensuring economic efficiency in the allocation and distribution of energy supplies.

Now that almost a decade has passed since the first major price increase of 1973, it is useful to evaluate our long run policy response to various developments in the world energy market (which have produced a lasting impact on the global economic system during the 1970s), and to institute changes that may be justified by articulating them in the approach to the Seventh Five Year Plan. Higher energy prices have not only been the trend of the past 10 years (notwithstanding the current downturn in oil prices), but would be inevitable in the long-term future as well. Consequently, the process of adjustment in the structure of the Indian economy to reflect past, and anticipated, energy price increases and energy scarcities, which should have progressed substantially during the last 10 years, merits evaluation and possible reorientation towards new directions. The importance of institutionalizing, through the planning process, this philosophy of long-term adjustment to higher energy scarcity, is crucially important for the following reasons:

1. Price changes cannot be treated as the sole instrument for bringing about optimal adjustments, since, in general, there is likely to be significant divergence between market prices and shadow prices;

2. India has been following the path of building a self-reliant economy, through planned economic development. Consequently, changes desired have to be considered in the formulation of successive Five Year Plans;

3. The empirical evidence, thus far, has shown that readjustment of the Indian economy in response to growing energy scarcities has not been as rapid as achieved in various other countries of the world, both developed and developing.

The Government should, therefore, address the objective of higher energy efficiency while formulating the Seventh Five Year Plan.

For the country to reduce dependence on imports of oil and to ensure stable economic growth the development of indigenous energy supplies is an important national objective. However, two important questions arise in the context of energy supply development strategies:

1. At what price can the country afford indigenous development?

2. Is enhancement of indigenous supply capacity the only and most economically efficient means by which the gap between indigenous demand and supply can be bridged?

These can only be answered on the basis of a wide analysis of possible options in the energy sector and alternatives in resource allocation for the economy as a whole. In order to do so we must, therefore, consider the role of the energy sector vis-a-vis other sectors of the economy, and analyse various linkages between energy and the economy.

In considering the above questions, the issue of optimal resource allocation, inevitably, must be addressed. While this can be investigated at the micro level on a project to project basis, the overall macroeconomic implications of resource allocation for energy developments must be examined as well. Any misallocation of resources used for energy supply would in a short period of time lead to faltering in the tempo of economic development. India's planned response to the energy crisis of the 1970s has led to a higher share of resources being allocated to indigenous energy supplies. he impact of the increased expenditure for oil imports on overall economic growth can be inferred from some broad (almost simplistic) figures indicating the relative growth of GDP in India vis-a-vis other groups of countries, as shown in Table 1.

Table 1: Relative Average Annual Growth Rates of GDP
(Using Indian Growth Rates As Numeraire)

	1960.73	1973.80	1980	1981
1. All developing countries	1.65	1.21	.61	.39
2. Low income countries	1.17	1.18	.90	.69
3. India	1.00	1.00	1.00	1.00
4. Asia	1.08	1.37	.84	1.05
5. East Asia & Pacific	2.34	1.97	.54	1.28
6. Latin America & Caribbean	1.68	1.42	.86	- .45
7. Sub-Saharan Africa	1.25	.87	.64	.30
8. Southern Europe	2.00	.89	.21	.36

Source: World Bank, World Development Report, 1983, Table No. 2.6.

India's record after 1973, particularly considering its relatively poor performance in the period 1960-73, has been quite heartening as compared to other groups of countries. But its performance in relation to Asia, and the grouping of East Asia and the Pacific nations has not been entirely favourable, particularly after 1980. Even though quantitative estimates of the determinants of slower economic growth and their precise effects are not available, it can be argued on the basis of data available that among various factors which are proving to be detrimental to economic growth, the following are significant:

1. The relatively high growth of demand for petroleum and petroleum products, resulting in larger import bills particularly in the period immediately after 1979-80;

2. Inefficient utilization of capital invested in the electric power supply industry in India;

3. High intensity of energy use in most sectors of the economy and low levels of thermodynamic or thermal efficiency in most end uses.

Planned Outlays On Energy And Energy Efficiency

These factors have not been fully taken into account in our plans and resource allocation decisions because India's policy response to the international energy problem has been mainly to enhance its own base for supply of energy. This has resulted in relatively large allocations for the energy sector as a whole and the power supply industry in particular.

Table 2 (a) shows investments made in the power sector in successive five year plans, and Table 2 (b), actual outlays in various components of energy supply in each year of the Sixth Plan.

Table 2(a): Investment in Power Sector

	Investment Rs. Crore	% of total plan public sector outlay
I Plan	320	16.3
II Plan	625	11.2
III Plan	1334	15.6
Three Annual Plans	1817	27.4
IV Plan	2523	16.0
V Plan	7294	18.6
VI Plan (Plan Document)	15750	22.6

Source: Report of the Working Group on Energy Policy, Planning Commission, New Delhi, 1979.

Table 2(b): Investments in Energy Sector
(Sixth Five Year Plan)

Energy Form	1980-85 Crores	%	1980-81 Crores	%	1981-82 Crores	%	1982-83 Crores	%	1983-84 Crores	%
Electricity	19625	72.9	2708	69.9	3291	67.2	3950	58.2	4655	55.1
Oil	4300	16.0	710	18.3	1011	20.6	1939	28.6	2815	33.3
Coal	2870	10.65	448	11.5	578	11.8	877	12.9	946	11.2
New Energy Sources	100	0.4	10	0.2	15	0.3	22	0.3	30	0.3
Total*	26895	27.5	3876	26.3	4894	28.0	6788	32.1	8446	33.1

* The percentages here correspond to that of total energy investments to total investments.

Source: Computed by the authors.

Within the Sixth Five Year Plan itself, annual expenditure has exhibited some shift in favour of hydrocarbons which understandably, is induced by reasons of high import costs. But, undoubtedly, this temporary shift in priorities also represents in a roundabout way the effects of differences in efficiency of capital used. For instance, failures in supply of electric power have led to rapid increase in demand for petroleum products, particularly middle distillates used for captive power generation and diesel pumping sets. At the same time, the total investment in energy as share of planned total outlay has inched upwards during the period 1980-81 to 1983-84.

These developments must be viewed against the fact that the efficiency with which the power supply industry has employed resources in the past has been on the decline. Evidence of this is provided in assessments made in the report of the Committee on Power and the mid-term review of the Sixth Plan. this is also evident from the accumulation of losses of the state electricity boards and the growth of captive power generation in the industrial sector, in response to failures and unreliable supply from the power utilities.

Higher efficiency in the use of energy should, therefore, become the cornerstone of future economic planning in India, or else the energy supply industry (in particular the state electricity boards) would only weaken further under the burden of higher expansion of their operations, quite apart from the economic merits of higher energy efficiency. It must also be emphasised that the inefficiency of the power supply industry in India is highly understated by considering mere financial performance. If account was to be taken of the resources expended in provision of voltage stabilisers, standbye diesel pumps for irrigation, and damages to equipment and increased wear or failure of electrical appliances due to faulty or interrupted power supply, then the assessment of economic losses would be considerably higher.

The justification for higher energy efficiency and rational management of energy demand is not only applicable to the Indian situation, but also holds true for a number of other developing countries. The World Bank* in its latest study on this subject has explored the potential for energy savings in the developing nations through a range of demand management measures.* This report also draws attention to the record of a number of developed nations in which energy consumption per tonne of steel and cement declined by 5-15% between 1975 and 1979. The share of petroleum fuels in industrial energy consumption declined between 1973 and 1980 from 60-57% in Japan, from 52-43% in Germany, and from 54-41% in the U.K., through the increasing substitution of natural gas, coal, lignite, and electric power.

The Bank's report also contends that category A savings in industrial energy consumption, which include small investments in implementing combustion efficiency improvements, insulation, steam system efficiency improvements, and other housekeeping measures generally, have payback periods of between 10 and 20 months. Even Category B savings, which generally require larger investments in retrofitting existing plants, waste heat recovery systems, etc., yield paybacks in two to five years. Undoubtedly, the almost complete absence of investments in higher industrial energy efficiency in India has been due to an unsustainable emphasis on energy production capacity. This has led not only to a lack of attention to efficient energy use in the past, but has also brought about imbalances in investments in power transmission and distribution facilities, and in measures for reducing refinery losses.

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* The World Bank, The Energy Transition in Developing Countries, Washington, D.C., August 1983.

While the scope for efficiency improvements in energy use is considerable in transport and agriculture and in households, the potential for quick results is greatest in the industrial sector. Consequently, within the framework of a five year plan, savings from energy conservation in industry are both attainable and significant, justifying overriding emphasis on, and priority for, this approach in the Seventh Plan.

The reduction of energy consumption in India's industrial sector is a challenge that can be evaluated through an analysis of feasible options. Table 3 shows the intensity of energy use in selected industries in India in comparison with some other nations. (Due to paucity of data we have restricted this comparison only to developed countries, but it is known that countries like the Republic of Korea, Taiwan and, in certain sectors, even the Philippines are not lagging far behind industrialized nations.)

Table 3: Energy Intensities in Selected Industries

	Steel	Cement	Alumi-nium	Pulp & Paper	Ferti-lizer	Texti-les
India	9.50	2.00	33.00	11.13	11.25	22.40
Italy	4.03	0.89	-	-	9.92	-
Japan	4.18	1.20	13.90	-	-	-
Sweden	5.02	1.40	16.50	7.56	-	-
UK	6.07	1.30	21.10	7.62	12.23	-
USA	6.06	0.95	9.50	9.70	11.32	12.10
West Germany	5.21	0.82	14.90	-	-	-
(India-lowest / India) (%)	57.6	59.0	71.2	32.1	11.8]	46.0
(India-highest / India) (%)	36.1	30.0	36.1	12.8	- 8.7]	

Source: Indian figures are the author's estimates (1979-80) taken from the most reliable of recent sources.
Figures for other countries are taken primarily from Jankowski (1981) with the exception of Steel (National Productivity Council 1981 seminar) and Paper (National Productivity Council, 1983 Sectoral Report)

Undoubtedly, international comparisons of energy intensity can prove misleading, unless account is taken of factors such as the relative prices of various fuels, the vintage of capital employed in each industry, and the price of energy in relation to prices of other factors including capital, labour and other materials. Energy intensity is, therefore, essentially a thermodynamic concept, but assumes relevance in international comparisons on account of the global increase in energy prices.

Energy Conservation Potential

Considering the prime organized user of energy in the Indian economy, namely, the industrial sector, it can be seen from the figures presented in Table 4 that energy conservation measures can be divided into three types:

1. Short-term measures, which require little or no capital investment;
2. Medium-term, which require some capital investment;
3. Long-term, which require major modifications in processes and significant capital investments.

Table 4: Potential Energy Saving In Industrial Sector

Conservation measures	Energy Savings: Million tonnes coal equivalent	Energy Savings: Rs.Crores	Investment Rs.Crores
Short-term House-keeping & Insulation	7.8	700	400
Medium-term Waste Heat Recovery Instrumentation Control Replacement with energy efficiency	9.4	840	1200
Long-term Process changes Computer Control Cogeneration	6.2	560	2000

Source: Inter-Ministerial Working Group on Utilization and Conservation of Energy, Summary volume, pp.15-16.

Energy conservation potential in Indian industry ranges from 5-15% in the short-run and between 15-30% in the medium term. When these measures are considered at the aggregate level, energy savings from the six selected industries shown in Table 5 would amount to Rs. 275.7 crores in the short and medium term. This is equivalent to a saving of 9.5 million barrels of oil, or 20 million tonnes of coal.

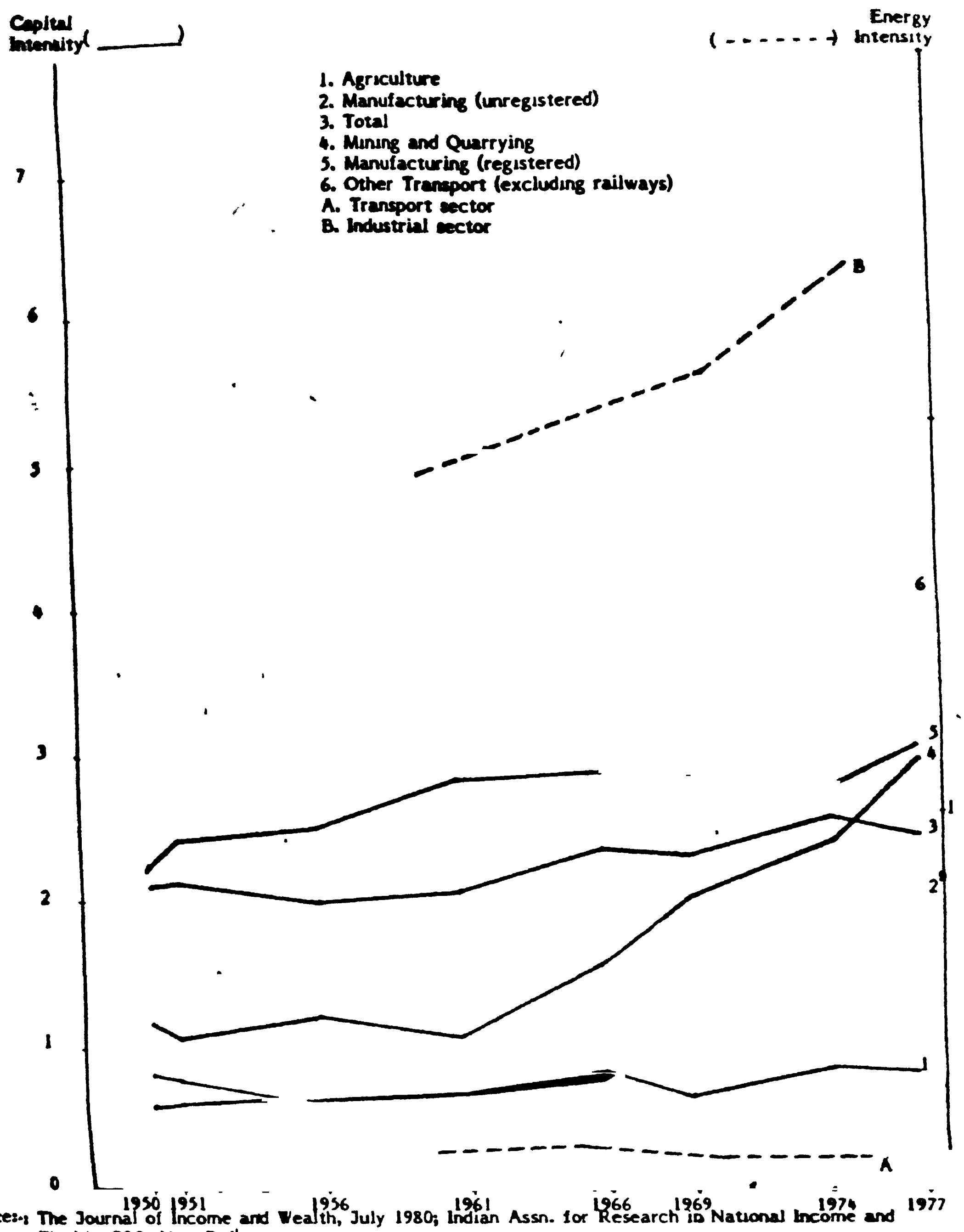
Table 5: Energy Conservation Potential In Selected Industries

	Short-term		Total	
	Percent	Rs.million/ year	Percent	Rs.million/ year
Steel	8	414	19	983
Cement	5	65	14	181
Aluminium	15	114	30	228
Pulp & Paper	6	49	18	146
Fertilizer	6	108	15	270
Textiles	10	327	29	949

Source: Compiled by the authors.

At the core of understanding any energy conservation approach is the relationship between energy, capital, labour and materials. Most research in other countries, based on estimation of production functions involving these four separate factors, seems to indicate that generally energy and capital are complementary in the short run, but turn out to be substitutes in the long run. The importance of lags in adjustment of capital stock, and diffusion of new technologies, is critical to the nature of the energy-capital relationship. For instance, in the case of the transport sector where the replacement of, and addition to, the existing capital stock is relatively rapid, it is apparent that technological change can take effect faster than, say, in the case of the industrial sector. But with measures not involving capital stock changes, the industrial sector response is faster through a substitution of managerial inputs and labour.

Figure - Trends in Capital and Energy Intensities



Sources:- The Journal of Income and Wealth, July 1980; Indian Assn. for Research in National Income and Wealth, CSO, New Delhi.

The trends in the intensities of capital employed and energy intensities shown in the preceding figure imply a capital energy complementarity for the industrial sector, but the relationship is not that clear in the case of the transport sector. Undoubtedly, there is in effect a complementary relationship evident in the trends of capital intensity and energy intensity in the transport sector as well. But in these simple figures this effect is obscured due to the dominating effect of new additions to the transport fleet in recent years, with technological improvements leading to declines in capital intensity as well as fuel intensity. These results underline the efficacy of improved technical designs in the stock of transportation equipment that are likely to be introduced in the Seventh Five Year Plan. In short, technical improvements incorporated in the introduction of transport equipment would have a measurable impact even in the short run.

Macro Implications Of Energy Conservation

Based on the trends of the past, the income elasticity of energy demand, which can be measured in terms of the ratio of annual growth in demand for energy, and the growth in GNP of the Indian Economy, some time-related variations are in evidence. We have computed the elasticity of energy demand by first considering commercial energy consumption only, and then by including both commercial and non-commercial energy consumption. The results for selected periods are shown below:

Table 6: Income Elasticity Of Energy Demand

	1973-75	1977-78	1979-81	1973-81
1.Commercial energy	1.23	0.66	1.02	1.36
2.Total energy (including non-commercial)	0.80	0.56	0.68	0.81

Source: 1.National Energy Data Report, India, 1981.
2.Report of the Working Group on Energy Policy, Planning Commission, New Delhi, 1979.

Note: The 1973-81 value is higher than the other estimates presented, due to relatively high values during the periods not shown.

The above figures appear different from those produced in official publications in the past, notably the Report of the Working Group on Energy Policy, mainly because we have used oil equivalent measures instead of conventional coal replacement figures used in such computations in the past. The change between 1977-78 and 1979-81 appears disquieting and confirms the discussion presented above, i.e. India did reasonably well in curbing energy consumption relative to economic growth in the wake of the first oil shock, but the response has not been matched after the second oil shock.

We now return to the question posed earlier on the possibility of pursuing a lower energy intensity strategy without sacrificing economic growth. The specific answer to this question lies, as mentioned earlier, in considering the trade off between energy conservation and additions to energy production capacity. we have, as an example, selected five major industries for a quick evaluation of the economies of energy conservation as against provision for new supply capacity, based on average costs of supplying coal at Rs.23.34/10^6 Kilo calories (KCal) and diesel oil at Rs.216.20/10^6 KCal respectively.* These projects are listed in Table 7, and for each project the following calculations were carried out:

1. Net present value of total project cost in 1980 rupees;
2. Annual energy savings as a result of project implementation in million kilo calories;
3. Supply price of annual energy savings in 1980 rupees per million kilo calories.

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* Ministry of Energy, Indian Petroleum & Petrochemical Statistics 1982-83, Government of India, New Delhi; National Council of Applied Economic Research, Personal Communications 1983.

Table 7: Selected Industrial Conservation Projects In India

Project Number	Description	Project Category	NPV of total project cost 1980 rupees	Energy savings per year K-cal x 10^9	Supply Price 1980 Rs./ 10^6 K.cal
1.	Steel (industry-wide)				
1.1.	Sizing of raw materials	A	112450000	1066.7	9.31
1.2.	Use of LD converters	C	1919500000	5000.0	33.76
2.	Cement (specific company)				
2.1.	Use of dry process	C	471896000	1814.0	25.09
2.2.	Addition of Pre-calcinators	C	96134000	263.4	35.20
3.	Chemicals (specific company)				
3.1.	Heat recovery from blow-down	B	26192	0.22	11.48
3.2.	Addition of waste heat recovery boiler	B	654800	2.00	31.57
4.	Textiles (specific company)				
4.1.	Insulate cylindrical dryers	A	20954	0.42	4.81
4.2.	Waste heat recovery in thermic boiler	B	114590	5.40	2.05
4.3.	Heat recovery from boiler blow-down	B	94693	1.75	4.76
5.	Food Processing (specific project)				
5.1.	Insulate bare steam lines	A	321	0.0119	26.96
5.2.	Pre-heat furnace oil by flue gases	B	3206	0.0357	22.45
	TOTAL		2601395000	8153.94	28.06

Note: Project Category: A. Insulation and general housekeeping
B. Waste Heat Recovery
C. Process Changes

It is clear that all the selected projects are less costly than the supply of a new barrel of oil. In particular, simple housekeeping measures are overwhelmingly economical. Those measures which require major capital investment are not as economical. However, even process modifications appear more economical than new oil supply. Energy conservation, in addition, makes sense in an environment of severe capital constraints. For instance, it has been estimated that to obtain an energy saving of 25% in the total industrial sector (i.e. equivalent to approximately 23.4 MTCE, Rs. 3,600 crores of investment would be required. This should be compared to the original Sixth Plan outlay for the energy sector of Rs.26,535 crores. In other words, total government and private sector investments for industrial energy conservation would be a mere 14% of the total public sector outlay for energy originally planned for 1980-85. Of this total investment, the government's contribution in terms of direct investment in public sector undertakings, and government revenues (i.e. taxes) foregone due to incentive schemes such as depreciation allowance and tax credits, is not expected to be more than 50-60%. this will further reduce the expected diversion of government outlays for outlays conservation to less than 8% of the expected outlays in the energy sector, since incentives and subsidies will bring forth private investments to fill the balance.

The question of incentives and disincentives also requires deeper analysis than attempted thus far. For instance, in the study of a glass factory undertaken by the Tata Energy Research Institute (TERI), it was revealed that the recent listing of energy conserving equipment qualifying for 100% depreciation needs reevaluation. While cogeneration equipment qualified for such depreciation, a much larger system, based on shifting energy use in the glass factory from diesel oil and other hydrocarbons to a totally coal-based producer gas scheme, did not. In the absence of suitable incentives the producer gas system designed by TERI fell somewhat short of financial viability.

Conclusions

In conclusion, it would be useful to identify some measures that need to be taken in order to move the Indian Economy on a lower energy intensive path and to accelerate the process of adjustment in response to increased energy scarcity.

1. It is important to carry out fairly rigorous studies of the trade off between enhanced energy supply capacity and energy conservation on a sector by sector basis. This is partcularly important for the industrial sector, wherein pay off from even small energy investments is expected to be large and rapid.

2. Allocation of resources in the Seventh Five Year Plan could be made to fall in line with maximising national income and economic welfare on the basis of these trade offs, by appropriate investments in energy conserving measures.

3. The speed at which energy conservation can be realized, and associated technological change and capital investments brought about, also needs to be evaluated on a sector by sector basis. On this would depend the choice of a time-related resource allocation plan within a capital budgeting framework.

4. An identification of incentives and disincentives as instruments for promoting lower energy intensive development would need to be made, such as:

   a. Reviewing current subsidies and price differentials for different groups of customers, particularly those available to industrial consumers;

   b. Rationalising the price of coal by bringing in spatial considerations and transportation costs.

Undoubtedly, these questions need not be looked at afresh by the Planning Commission, since some of them have already been investigated by the IMWG and other organizations. But, it would be most desirable and timely to take into account the findings of the IMWG and other such work available in formulating the Seventh Five Year Plan.